

November 8, 2004

Mr. Daniel J. Malone
Site Vice President
Palisades Nuclear Plant
Nuclear Management Company, LLC
27780 Blue Star Memorial Highway
Covert, MI 49043-9530

SUBJECT: PALISADES PLANT - REQUEST RELIEF FROM AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME) SECTION XI CODE REQUIREMENTS FOR REPAIR OF REACTOR PRESSURE VESSEL HEAD PENETRATIONS (TAC NO. MC3931)

Dear Mr. Malone:

By letter dated August 2, 2004, as supplemented by letters dated August 19, October 4, and October 28, 2004, Nuclear Management Company, LLC (NMC or the licensee) requested relief from certain sections of the ASME Boiler and Pressure Vessel (B&PV) Code, Section XI, 1989 Edition. The licensee requested two reliefs pertaining to the repair of the reactor vessel head penetrations. The licensee submitted the relief requests in the event that a reactor vessel head nozzle penetration would require repair. The two relief requests that were submitted are as follows:

Relief Request No. 1 - Alternate Repair Technique for Reactor Vessel Head Penetrations

NMC is requesting relief from ASME Section XI, 1989 Edition, IWA-4120, pursuant to Chapter 10 of the *Code Of Federal Regulations* (10 CFR) 50.55a(a)(3)(i), because the alternative provides an acceptable level of quality and safety. The licensee requests relief to use an ambient temperature temper bead method of repair as an alternative to the requirements of the 1989 Edition of ASME Section III, NB-4453, NB-4622, NB-5245, and NB-5330. The licensee proposes to use filler material, Alloy 52 AWS Class ERNiCrFe-7/UNS No. 06052, which is endorsed by Code Case 2142-1, "F-Number Grouping for Ni-Cr-Fe, Classification UNC N06052 Filler Material," for the weld repair.

Relief Request No. 2 - Flaw Characterization of Remnant Weld

NMC is requesting relief from ASME Section XI, IWA-3300(b), IWB-3142.4, and IWB-3420, pursuant to 10 CFR 50.55a(a)(6)(i) because the alternative provides an acceptable level of quality and safety. The above sections would require characterization of a flaw existing in the remnant of the J-groove weld that will be left on the reactor vessel closure head (RVCH) if a control rod drive (CRD) or incore instrumentation nozzle must be partially removed.

During the current refueling outage, the licensee inspected the reactor vessel head and penetrations in accordance with U. S. Nuclear Regulatory Commission (NRC) Order, EA-03-009. During the inspection, the licensee identified through-weld cracks in the Inconel buttering adjacent to the J-weld on reactor head penetrations 29 and 30. The licensee

determined that penetrations 29 and 30 would require repair, and that the requested code relief was required.

The NRC staff has completed its review as documented in the enclosed safety evaluation (SE). For Relief Request No. 1 - Alternate Repair Technique for Reactor Vessel Head Penetrations, the NRC staff determined that the proposed alternatives provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the staff authorizes Relief Request No. 1 through the end of the third 10-year inservice inspection interval at the Palisades Nuclear Plant. The third 10-year inservice inspection interval ends on or before December 12, 2006.

For Relief Request No. 2 - Flaw Characterization Of Remnant Weld, the NRC staff has determined that the compliance with the code requirements are impractical. Therefore, pursuant to 10 CFR 50.55a(g)(6)(i) the staff grants Relief Request No. 2 through the end of the third 10-year inservice inspection interval at Palisades Nuclear Power Plant. The third 10-year inservice inspection interval ends on or before December 12, 2006.

Pursuant to 10 CFR 2.390, the NRC staff determined that the enclosed SE does not contain proprietary information. However, we will delay placing the SE in the public document room for 10 working days from the date of this letter to provide you with the opportunity to comment on the proprietary aspects only. If you believe that any information in the enclosure is proprietary, please identify such information line by line and define the basis pursuant to the criteria of 10 CFR 2.390.

While performing the final reviews of the weld repair implementation modification package on the CRD nozzles, the licensee discovered that the current technical specifications (TSs) which control the cooldown limits were not conservative, and additional restrictions would have to be added to the TSs to protect the integrity of the reactor vessel head.

To facilitate the repair in accordance with its outage schedule, the licensee requested verbal authorization of the relief requests. In a telephone conversation with the licensee on October 28, 2004, the NRC staff verbally authorized the use of Relief Request No. 1 and Relief Request No. 2. The NRC staff stated that the verbal authorization is contingent upon the licensee's commitment to submit, and NRC approval of, a license amendment to add restrictions to the cooldown limits in the TSs. The license amendment will add restrictions to the TSs, bounding the fracture mechanics analysis supporting the relief requests, in order for the plant to remain in compliance with 10 CFR 50.55a.

In the October 28, 2004, supplement letter, the licensee confirmed that a license amendment is necessary to modify the cooldown limits specified in Technical Specification Limiting Condition for Operation 3.4.3 "PCS Pressure and Temperature (P/T) Limits" to support these repairs. By letter dated November 2, 2004, the licensee submitted the license amendment. The NRC approval of the license amendment will be under a separate cover. This letter documents the NRC written authorization of the proposed relief requests.

D. Malone

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A copy of our related safety evaluation is also enclosed.

If you have any questions regarding this issue, please contact Mr. John F. Stang at 301-415-1345 or by e-mail at jfs2@nrc.gov.

Sincerely,

/RA/

L. Raghavan, Chief, Section 1
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-255

Enclosure: Safety Evaluation

cc w/encl: See next page

Palisades Plant

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October 2003

D. Malone

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REACTOR VESSEL CLOSURE HEAD NOZZLE PENETRATION REPAIR

THIRD 10-YEAR INSERVICE INSPECTION INTERVAL

RELIEF REQUEST NOS. 1 AND 2

PALISADES NUCLEAR PLANT

NUCLEAR MANAGEMENT COMPANY

DOCKET NO. 50-255

1.0 INTRODUCTION

By letter dated August 2, 2004, as supplemented by letters dated August 19, October 4, and October 28, 2004, Nuclear Management Corporation (the licensee) requested relief from certain sections of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, 1989 Edition. The licensee requested two reliefs pertaining to the repair of the control rod drive nozzles and incore instrumentation nozzles. During the current refueling outage, the licensee inspected the reactor vessel head and penetrations in accordance with Nuclear Regulatory Commission (the Commission or NRC) Order, EA-03-009. During the inspection, the licensee identified through-weld cracks in the Inconel buttering adjacent to the J-weld on reactor head penetrations 29 and 30. The licensee had submitted the relief requests in the event that a reactor vessel closure head nozzle penetrations required repair. The licensee determined that penetrations 29 and 30 would require repair and that NRC authorization of the relief requests was required.

2.0 REGULATORY EVALUATION

The inservice inspection of the ASME Code Class 1, Class 2, and Class 3 components is to be performed in accordance with the ASME Code Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," and applicable edition and addenda as required by Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(g), except where specific relief has been granted by the Commission. Pursuant to 10 CFR 50.55a(a)(3) alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if the applicant demonstrates that: (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Pursuant to 10 CFR 50.55a(g)(6)(i), the Commission may grant relief and may impose alternative requirements as it determines is authorized by law and will not endanger life or property or the common defense and security and is in the public interest giving due consideration to the burden upon the licensee if the requirements were imposed on the facility.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) will meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code Section XI to the extent practical within the limitations of design, geometry, and materials of construction of the

components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein.

The original construction code for the Palisades Nuclear Plant is ASME Section III, 1965 Edition, including addenda through winter 1965. The inservice inspection code of record for Palisades' third 10-year interval is the 1989 Edition of ASME Section XI, no addenda.

3.0 BACKGROUND

To repair the flaws in the reactor vessel head penetrations 29 and 30, the licensee will implement a Framatome Advanced Nuclear Product (FANP) design repair. In the October 4, 2004, letter, the licensee provided a brief summary of the repair procedures of the control rod drive and incore instrumentation nozzles as follows:

Palisades has a long nozzle extension that attaches to the bottom of the existing nozzle and a grid structure is tied to the lower portion of the nozzle extension. Before the repair, the weld repair area is initially examined by the ultrasonic technique. The tube grid structure adjoining the target nozzle and surrounding control rod drive mechanism are cut. A cut is made on the nozzle in the reactor vessel closure head penetration a few inches above the J-groove weld and the lower part of the nozzle is removed. The nozzle extension close to the underside of the head is also removed. The remnant nozzle in the reactor vessel closure head penetration is roll-expanded and the bore is cleaned. The lower nozzle region of the penetration is bored slightly oversize up to the location of the repair weld and the lower portion of the remnant nozzle is beveled suitable for welding.

The original attachment J-groove weld is chamfered to reduce its size. The weld area is cleaned and examined with liquid penetrant. The weld preparation area, nozzle, and crevice are dried using heating element before repair weld is applied. The new replacement lower nozzle is fabricated with Alloy 690 material. The replacement nozzle is inserted into the penetration and welded to the bore of the penetration using the machine gas tungsten arc welding technique based on the ambient temperature temper bead process. A 48-hour cool down period is applied after the welding. The new weld is machined to re-establish a free-path inside of the nozzle. This may be performed during the 48-hour hold time. An ultrasonic testing is performed on the new weld after the 48-hour hold period.

A temporary foreign material exclusion plug is installed on the top of the nozzle so that abrasive waterjet can be performed on the inside surface of the repaired nozzle, including the region above the roll transition, original lower nozzle, and weld. After the waterjet, the remediated area is visually inspected and the temporary plug is removed.

A penetrant testing is performed on the new weld and roll-expanded portion of the nozzle, including the roll transition region and waterjet area. The new extension assembly is welded to the bottom of the replacement nozzle and tube grid structure for control rod drive mechanism locations is installed. The new tube grid structure and the new extension assembly (control rod

drive only) are visually inspected. The completed control rod drive nozzle modification is verified for free path. Final cleaning and visual inspection of each nozzle is performed.

4.0 RELIEF REQUEST NO. 1-ALTERNATE REPAIR TECHNIQUE FOR REACTOR VESSEL HEAD PENETRATIONS

4.1 COMPONENTS FOR WHICH RELIEF IS REQUESTED

The components for which relief is requested are the reactor vessel closure head, 45 control rod drive nozzle penetrations, and 8 incore instrumentation nozzle penetrations.

4.2 APPLICABLE ASME CODE EDITION AND REQUIREMENTS

The licensee stated that the 1989 Edition of ASME Section XI, no addenda is applicable to the proposed repairs. The applicable code requirement for the reactor vessel closure head penetration repair is ASME Section XI, IWA-4120, as follows:

(a) Repairs shall be performed in accordance with the owner's design specification and the original construction code of the component or system. Later editions and addenda of the construction code or of Section III, either in their entirety or portions thereof, and code cases may be used. If repair welding cannot be performed in accordance with these requirements, the applicable alternative requirements, of IWA-4500 and the following may be used:

- (1) IWB-4000 for Class 1 components;
- (2) IWC-4000 for Class 2 components;
- (3) IWD-4000 for Class 3 components;
- (4) IWE-4000 for Class MC components; or
- (5) IWF-4000 for component supports.

(b) The edition and addenda of Section XI used for the repair program shall correspond with the edition and addenda identified in the inservice inspection program applicable to the inspection interval.

(c) Later editions and addenda of Section XI, either in their entirety or portions thereof, may be used for the repair program, provided these editions and addenda of Section XI at the time of the planned repair have been incorporated by reference in amended regulations of the regulatory authority having jurisdiction at the plant site.

4.3 LICENSEE'S PROPOSED ALTERNATIVE

The licensee requested relief to use a welding repair method that is based on an ambient temperature temper bead method as an alternative to the requirements of the 1989 Edition of ASME Section III, NB-4453, NB-4622, NB-5245, and NB-5330. Approval is requested to use filler material, Alloy 52 American Welding Society (AWS) Class ERNiCrFe-7/UNS No. 06052, which is endorsed by Code Case 2142-1, "F-Number Grouping for Ni-Cr-Fe, Classification UNC N06052 Filler Material," for the weld repair.

Portions of Code Case N-638, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine [Gas Tungsten Arc Welding] GTAW Temper Bead Technique," which has been approved in Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability - ASME Section XI Division 1," Revision 13, are also applicable to this repair.

As an alternative to these requirements, the licensee will use the welding technique as discussed below. Because of the risk of damage to the reactor vessel closure head material properties or dimensions, and the additional radiological dose that would be required, it is not feasible to apply the post-weld heat treatment requirements of paragraph NB-4622 of the 1989 ASME Section III Code to the reactor vessel closure head or the elevated temperature preheat and post weld soak required by the alternative temper bead method offered by ASME Section XI IWA-4500. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the licensee requests relief to use an ambient temperature temper bead welding method as an alternative to the welding requirements of ASME Section III, NB-4622, 1989 Edition, no addenda.

The licensee proposed the following alternatives to the specific sections of the ASME Sections III, IX, and XI requirements:

1. NB-4622.1 establishes the requirement for post-weld heat treatment of welds including repair welds. In lieu of these requirements, the licensee proposes to use a temper bead weld procedure, which would preclude the need for post-weld heat treatment.
2. NB-4622.2 establishes requirements for time at temperature recording of the post-weld heat treatment and their availability for review by the inspector. This does not apply because the proposed alternative does not involve post-weld heat treatment.
3. NB-4622.3 addresses the definition of nominal thickness as it pertains to time at temperature for post-weld heat treatment. This is not applicable because the proposed alternative involves no post-weld heat treatment.
4. NB-4622.4 establishes the holding times at temperature for post-weld heat treatment. This is not applicable because the proposed alternative involves no post-weld heat treatment.
5. NB-4622.5 establishes post-weld heat treatment requirements when different P-number materials are joined. This is not applicable because the proposed alternative involves no post-weld heat treatment.
6. NB-4622.6 establishes post-weld heat treatment requirements for nonpressure retaining parts. This is not applicable because the potential repairs in question will be to pressure retaining parts. Furthermore, the proposed alternative involves no post-weld heat treatment.
7. NB-4622.7 establishes exemptions from mandatory post-weld heat treatment requirements. NB-4622.7(a) through NB-4622.7(f) are not applicable in this case because they pertain to conditions that do not exist for the proposed repairs. NB-4622.7(g) addresses exemptions to weld repairs to dissimilar metal welds if the requirements of subparagraph NB-4622.11 are met. This does not apply because the ambient temperature temper bead repair is being proposed as an alternative to the requirements of NB-4622.11.

8. NB-4622.8 establishes exemptions from post-weld heat treatment for nozzle to component welds and branch connections to run piping welds. NB-4622.8(a) establishes criteria for exemption of post-weld heat treatment for partial penetration welds. This is not applicable to the proposed repairs because the criteria involve buttering layers at least 1/4-inch thick, which will not exist for the welds in question. NB-4622.8(b) also does not apply because it addresses full penetration welds and the welds in question are partial penetration welds.

9. NB-4622.9 establishes requirements for temper bead repairs to P-No. 1 and P-No. 3 materials and A-Nos. 1, 2, 10, or 11 filler metals. This does not apply because the proposed repairs will involve F-No. 43 filler metals.

10. NB-4622.10 establishes requirements for repair welding to cladding after post-weld heat treatment. This does not apply because the proposed repair alternative does not involve repairs to cladding.

11. NB-4622.11 addresses temper bead weld repair to dissimilar metal welds or buttering and would apply to the proposed repairs as follows:

A. NB-4622.11(a) requires surface examination prior to repair in accordance with NB-5000. The proposed alternative will include surface examination prior to repair consistent with NB-5000.

B. NB-4622.11(b) contains requirements for the maximum extent of repair including a requirement that the depth of excavation for defect removal not exceed 3/8-inch in the base metal. The proposed alternative will include the same limitations on the maximum extent of repair.

C. NB-4622.11(c) addresses the repair welding procedure and welder qualification in accordance with ASME Section IX and the additional requirements of Article NB-4000. The proposed alternative will satisfy these requirements, except for the stipulations of paragraph QW-256 of Section IX. In addition, NB-4622.11(c) requires that the welding procedure specification include the following requirements:

(1) NB-4622.11(c)(1) requires the area to be welded be suitably prepared for welding in accordance with the written procedure to be used for the repair. The proposed alternative will satisfy this requirement.

(2) NB-4622.11(c)(2) requires the use of the shielded metal arc welding process with covered electrodes meeting either the A-No. 8 or F-No. 43 classifications. The proposed alternative uses gas tungsten arc welding with bare electrodes and bare filler metal meeting the F-No. 43 classification.

(3) NB-4622.11(c)(3) addresses requirements for covered electrodes pertaining to hermetically sealed containers or storage in heated ovens. These requirements do not apply because the proposed alternative uses bare electrodes and bare filler metal that do not require storage in heated ovens because neither bare electrodes nor bare filler metal will pick up moisture from the atmosphere as covered electrodes may.

(4) NB-4622.11(c)(4) addresses requirements for storage of covered electrodes during repair welding. These requirements do not apply because the proposed alternative uses bare electrodes and bare filler metal, which do not require any special storage conditions to prevent the pick up of moisture from the atmosphere.

(5) NB-4622.11(c)(5) requires preheat of the weld area and 1.5 times the component thickness or five-inch band, whichever is less, to a minimum temperature of 350 °F prior to and during repair welding, and a maximum interpass temperature of 450 °F. Thermocouples and recording instruments shall be used to monitor the metal temperature during welding. The proposed ambient temperature temper bead alternative does not require an elevated temperature preheat. Interpass temperature measurements cannot be accomplished due to inaccessibility in the weld region. Therefore, the maximum interpass temperature will be determined by calculation.

(6) NB-4622.11(c)(6) establishes requirements for electrode diameters for the first, second, and subsequent layers of the repair weld and requires removal of the weld bead crown before deposition of the second layer. Because the proposed alternative uses machine gas tungsten arc welding, the requirement to remove the weld crown of the first layer is unnecessary and the proposed alternative does not include the requirement.

(7) NB-4622.11(c)(7) requires the preheated area to be heated from 450 °F to 660 °F for 4 hours after a minimum of 3/16-inch of weld metal has been deposited. The proposed alternative does not require this heat treatment because the use of the extremely low hydrogen gas tungsten arc welding temper bead procedure does not require the hydrogen bake out.

(8) NB-4622.11(c)(8) requires welding subsequent to the hydrogen bake out of NB-4622.11(c)(7) be done with a minimum preheat of 100 °F and maximum interpass temperature of 350 °F. The proposed alternative limits the interpass temperature to 350 °F (maximum) and requires the area to be welded be at least 50 °F prior to welding. This approach has been demonstrated to be adequate to produce sound welds.

12. NB-4622.11(d)(1) requires a liquid penetrant examination after the hydrogen bake out described in NB-4622.11(c)(7). The proposed alternative does not require the hydrogen bake out because it is unnecessary due to the low amount of hydrogen produced in the temper bead gas tungsten arc welding process.

13. NB-4622.11(d)(2) requires liquid penetrant and radiographic examinations of the repair welds and the preheated band after a minimum time of 48 hours at ambient temperature. Ultrasonic inspection is required if practical. The proposed alternative includes the requirement to inspect after a minimum of 48 hours at ambient temperature. Because the proposed repair welds are of a configuration that cannot be radiographed (due to limitations on access for source and film placement and the likelihood of unacceptable geometric unsharpness and film

density), the proposed alternative final inspection will be by liquid penetrant and ultrasonic examination.

14. NB-4622.11(d)(3) requires that all nondestructive examination be in accordance with NB-5000. The proposed alternative will comply with NB-5000, except that the progressive liquid penetrant examination required by NB-5245, will not be performed. In lieu of the progressive liquid penetrant examination, the proposed alternative will use liquid penetrant and ultrasonic examination of the final weld. The volumetric examination coupled with surface examination will provide a high level of confidence that the proposed welds are sound.

15. NB-4622.11(e) establishes the requirements for documentation of the weld repairs in accordance with NB-4130. The proposed alternative will comply with the requirement.

16. NB-4622.11(f) establishes requirements for the procedure qualification test plate. The proposed alternative complies with these requirements.

17. NB-4622.11(g) establishes requirements for welder performance qualification relating to physical obstructions that might impair the welder's ability to make sound repairs, which is pertinent to the manual shielded metal arc welding process. The proposed alternative involves a machine gas tungsten arc welding process and requires welding operators be qualified in accordance with ASME Section IX. The use of a machine process eliminates any concern about obstructions, which might interfere with the welder's abilities, because all such obstructions will have to be eliminated to accommodate the welding machine.

18. NB-4453.4 requires examination of the repair weld in accordance with the requirements for the original weld. The welds being made in accordance with the proposed alternatives will be partial penetration welds as described by NB-4244(d) and will meet the weld design requirements of NB-3352.4(d). For these partial penetration welds, paragraph NB-5245 requires a progressive surface exam (liquid penetrate or magnetic particle) at the lesser of one-half the maximum weld thickness or 1/2-inch, as well as on the finished weld. For the proposed alternative, the repair weld will be examined by a liquid penetrant and ultrasonic examination no sooner than 48 hours after the weld has cooled to ambient temperature in lieu of the progressive surface examinations required by NB-5245. The volumetric examination coupled with surface examination will provide a high level of confidence that the proposed welds are sound.

19. NB-5330(b) does not allow any cracks or incomplete penetration regardless of length. As a result of the welding process, a linear indication often occurs at the intersection of the reactor vessel closure head, the nozzle, and the first intersecting weld bead (triple point). The proposed alternative will allow this triple point indication to remain. The licensee's justification of this relief is discussed in Section 4.4 of this safety evaluation.

20. QW-256 of ASME Section IX requires that the maximum interpass temperature during procedure qualification be no more than 100 °F below that used for actual welding. The maximum interpass temperature during welding is specified to be 350 °F maximum. The maximum interpass temperature during the procedure qualification was less than 100 °F. The licensee's justification of this relief is discussed in Section 4.4 of this safety evaluation.

In addition to the above, the licensee also proposed the following alternatives to ASME Section XI Code Case N-638:

- (a) Code Case N-638 2.1(b) requires consideration be given to the effects of welding in a pressurized environment. This requirement is not applicable because the welding will not occur in a pressurized environment.
- (b) Code Case N-638 2.1(c) requires consideration be given to the effects of irradiation on the properties of materials in the core belt line region. This requirement is not applicable because the welding will be on the reactor vessel closure head, not in the reactor beltline region.
- (c) Code Case N-638 2.1(h) specifies Charpy V notch requirements for ferritic weld material of the procedure qualification. The filler material is F-No. 43, which is not ferritic. Therefore, this requirement does not apply.
- (d) Code Case N-638 3.0(c) requires a layer of weld reinforcement be applied and then machined to a flush surface. This requirement is not applicable because the welding will join dissimilar metals with non-ferritic weld filler metal.
- (e) Code Case N-638 3.0(d) specifies the maximum interpass temperature for field applications shall be 350 °F regardless of the interpass temperature during qualification. Code Case N-638 2.1(e) specifies the maximum interpass temperature for the first three layers of the test assembly shall be 150 °F. QW-256 specifies maximum interpass temperature as a supplementary essential variable that must be held within 100 °F above that used during procedure qualification.
- (f) Code Case N-638 3.0(e) requires care be taken to ensure that the weld region is free of all potential sources of hydrogen. The proposed alternative temper bead procedure uses a welding process that is inherently free of hydrogen.
- (g) Code Case N-638 4.0(b) requires the final weld surface and band around the area defined in Code Case N-638 1.0(d) to be examined using surface and ultrasonic methods. The purpose for the examination of the band is to assure all flaws associated with the weld repair area have been removed or addressed. However, the band around the area defined in paragraph Code Case N-638 1.0(d) cannot be examined due to the physical configuration of the partial penetration weld. The final examination of the new weld and immediate surrounding area within the bore will be sufficient to verify that defects have not been induced in the low alloy steel reactor vessel closure head material due to the welding process. Figures 3 and 4 in Attachment 1 to the August 2, 2004, submittal, indicate the area for penetrant testing and ultrasonic testing for the control rod drive and incore instrumentation penetration repairs. The ultrasonic testing will be performed by scanning from the inner diameter surface of the weld. The ultrasonic testing is qualified to detect flaws in the repair weld and base metal interface in the repair region, to the maximum practical extent. The ultrasonic testing acceptance criteria will be in accordance with NB-5330. The extent of the examination is consistent with the construction code requirements.

(h) Code Case N-638 4.0(c) requires areas which had weld-attached thermocouples attached to be ground and examined using a surface examination. This requirement will be met if thermocouples are used.

(i) Code Case N-638 4.0(e) requires ultrasonic testing acceptance criteria to be in accordance with IWA-3000. The proposed welding technique requires ultrasonic testing acceptance criteria in accordance with NB-5330, which is consistent with the original construction code requirements.

4.4 LICENSEE'S BASIS FOR THE PROPOSED ALTERNATIVE

The features of the alternative repair technique that make it applicable and acceptable for the repairs are described below:

(1) The proposed alternative will require the use of an automatic or machine gas tungsten arc welding temper bead technique without the specified preheat or post-weld heat treatment of the Construction Code. The alternative will be used to make welds of P-No. 3 material (reactor vessel closure head) to P-No. 43 material (control rod drive and incore instrumentation nozzle) using F-No. 43 filler material.

(2) The ambient temperature temper bead technique is based on research that has been performed by Electric Power Research Institute (EPRI) as discussed in EPRI Report GC-1 11050, "Ambient Temperature Preheat for Machine GTAW Temper bead Applications," dated November 1998. The research demonstrates that carefully controlled heat input and bead placement allow subsequent welding passes to relieve stress and temper the heat affected zone of the base material and preceding weld passes. Data presented in Tables 4-1 and 4-2 of the report show the results of procedure qualifications performed with 300 °F preheats and 500 °F post-heats, as well as with no preheat and post-heat. From that data, it is clear that equivalent toughness is achieved in base metal and heat affected zone in both cases. The ambient temperature temper bead process has been shown effective by research, successful procedure qualifications, and many successful repairs performed since the technique was developed.

(3) The temper bead procedure in NB-4622.11(c)(2) requires the use of the shielded metal arc welding process with covered electrodes. Even the low hydrogen electrodes, which are required by NB-4622, may be a source of hydrogen unless very stringent electrode baking and storage procedures are followed. The only shielding of the molten weld puddle and surrounding metal from moisture in the atmosphere (a source of hydrogen) is the evolution of gases from the flux and the slag that forms from the flux and covers the molten weld metal. As a consequence of the possibility for contamination of the weld with hydrogen, NB-4622 temper bead procedures require preheat and post-weld hydrogen bake-out. However, the proposed alternative temper bead procedure uses a welding process that is inherently free of hydrogen.

(4) Final examination of the repair welds would be by penetrant testing and ultrasonic testing, and would not be conducted until at least 48 hours after the weld had returned to ambient temperature following the completion of welding. Given the 3/8-inch limit on repair depth in the ferritic material, the delay before final examination would provide ample time for any hydrogen that did inadvertently dissolve in the ferritic material to diffuse into the atmosphere or into the

non-ferritic weld material, which has a higher solubility for hydrogen and is much less prone to hydrogen embrittlement cracking. Thus, in the unlikely event that hydrogen induced cracking occurs, it would be detected by the 48-hour delay in examination.

(5) Results of procedure qualification work undertaken to date indicate that the ambient temperature bead process produces sound and tough welds. Typical tensile test results have been ductile breaks in the weld metal.

(6) The P-No. 43 to P-No. 3 welding procedure specifies a maximum interpass temperature of 350 °F. The welding procedure was qualified with an interpass temperature less than 100 °F. Per QW-256, of ASME Section IX, an increase greater than 100 °F is a supplementary essential variable. The procedure qualification requirements recommended in Code Case N-638 impose a 150 °F maximum interpass temperature during the welding of the procedure qualification. This requirement restricts base metal heating during qualification that could produce slower cooling rates that are not achievable during field applications. However, this requirement does not apply to field applications, as a 350 °F maximum interpass temperature is a requirement in Section 3.0 of Code Case N-638. The higher interpass temperature is permitted because it would only result in slower cooling rates which could be helpful in producing more ductile transformation products in the heat affected zone.

FANP has qualified the machine gas tungsten arc welding of P-No. 3, low alloy steel base materials, to P-No. 43, nickel alloy base materials, with the ambient temperature temper bead weld technique in accordance with the rules of ASME Code Case N-638. The qualifications were performed on the same P-No. 3, Group No. 3 base material as proposed for the control rod drive and incore instrumentation penetration repairs, using the same filler material (i.e. Alloy 52 AWS Class ERNiCrFe-7) with similar low heat input controls as will be used in the repairs. Also, the qualifications did not include a post weld heat soak. Based on FANP prior welding procedure qualification test data using machine gas tungsten arc ambient temperature temper bead welding, quality temper bead welds can be achieved with 50 °F minimum preheat and no post weld heat soak.

(7) As discussed previously, NB-5245 requires progressive surface examination of the proposed partial penetration welds while the alternative requires final penetrant testing and ultrasonic testing, which will provide added assurance of sound welds. The original Construction Code required progressive penetrant testing in lieu of volumetric examination because volumetric examination is not practical for the conventional partial penetration weld configurations. In this case, the weld is suitable for ultrasonic testing and a final penetrant testing can be performed. The final examination of the new weld repair and immediate surrounding area within the band will be sufficient to verify that defects have not been induced in the low alloy steel reactor vessel closure head material due to the welding process. Figures 3 and 4 in Attachment 1 to the August 2, 2004, submittal, indicate the area for penetrant testing and ultrasonic testing for the control rod drive and incore instrumentation nozzle penetration repairs. Ultrasonic testing will be performed by scanning from the inside diameter surface of the weld. The ultrasonic testing is qualified to detect flaws in the repair weld and base metal interface in the repair region. Ultrasonic testing acceptance criteria will be in accordance with NB-5330 (with exception to NB-5330(b) for the triple point anomaly). The extent of examination is consistent with the construction code requirements.

The reactor vessel closure head preheat temperature will be essentially the same as the reactor building ambient temperature. Therefore, reactor vessel closure head preheat temperature monitoring in the weld region and the use of thermocouples is unnecessary and would result in additional personnel dose associated with thermocouple placement and removal. Consequently, preheat temperature verification by use of contact pyrometer on accessible areas of the reactor vessel closure head is sufficient. In lieu of using thermocouples for interpass temperature measurements, calculations show that the maximum interpass temperature will never be exceeded based on a maximum allowable low welding heat input testing, weld bead placement, travel speed, and conservative preheat temperature assumptions. The calculation supports the conclusion that using the maximum heat input through the third layer of the weld, the interpass temperature returns to near ambient temperature. Heat input beyond the third layer will not have a metallurgical effect on the low alloy steel heat affected zone.

A welding mockup on the full size Midland reactor vessel closure head, which is similar to the Palisades reactor vessel closure head, was used to demonstrate the welding technique described herein. During the mockup, thermocouples were placed to monitor the temperature of the closure head during welding. Thermocouples were placed on the outside surface of the reactor vessel closure head within a 5-inch band surrounding the control rod drive nozzle. Three other thermocouples were placed on the reactor vessel closure head inside surface. One of the three thermocouples was placed 1.5 inches from the control rod drive nozzle penetration, on the lower hillside. The other inside surface thermocouples were placed at the edge of the 5-inch band surrounding the control rod drive nozzle, one on the lower hillside, the second on the upper hillside. During the mockup, all thermocouples fluctuated less than 15 °F throughout the welding cycle. Therefore, for ambient temperature conditions used for this repair, maintenance of the 350 °F maximum interpass temperature will not be a concern.

(8) Ultrasonic examination will be performed in lieu of radiographic testing due to the repair weld configuration. Meaningful radiographic testing cannot be performed. The weld configuration and geometry of the penetration in the reactor vessel closure head provide an obstruction for the x-ray path and interpretation would be very difficult. Ultrasonic testing will be substituted for the radiographic testing and qualified to evaluate defects in the repair weld and at the base metal interface. This examination method is considered adequate and superior to radiographic testing for this geometry. The new structural weld is sized like a coaxial cylinder partial penetration weld. Construction rules of the ASME Code Section III require progressive penetrant testing of partial penetration welds. The Section III requirements for progressive penetrant testing were in lieu of volumetric examination. Volumetric examination is not practical for the conventional partial penetration weld configurations. In this case, the weld is suitable for ultrasonic testing and a final surface penetrant testing will be performed.

(9) The extent of penetrant testing examination is consistent with the construction code requirements. The final modification configuration and surrounding ferritic steel area affected by the welding is either inaccessible or extremely difficult to access. Penetrant testing of the accessible ferritic steel bore will be performed after removal by boring of the lower end of the existing control rod drive nozzle prior to welding.

The licensee also provided basis for the welding anomaly at the triple point, general corrosion of the reactor vessel closure head, and stress and fatigue analyses of the nozzles.

4.5 DURATION OF PROPOSED ALTERNATIVE

The licensee requested approval of the proposed alternative for the remainder of the third 10-year interval of the inservice inspection program for the Palisades Nuclear Plant, which will conclude on or before December 12, 2006.

4.6 STAFF EVALUATION

4.6.1 LICENSEE'S PROPOSED ALTERNATIVE

The 1989 Edition of ASME Section III, paragraph NB-4622.11, "Temper Bead Weld Repair to Dissimilar Metal Welds or Buttering" states that whenever post-weld heat treatment is impractical or impossible, limited weld repairs to dissimilar metal welds of P-No. 1 and P-No. 3 material or weld filler metal A-No. 8 (Section IX, QW-442) or F-No. 43 (Section IX, QW-432) may be made without post-weld heat treatment or after the final post-weld heat treatment provided the requirements of the paragraphs NB-4622.11(a) through (g) are met. The NRC staff's evaluation of specific deviation from the ASME Code requirements is discussed as follows:

NB-4622.1 through NB-4622.7 establish various requirements for post-weld heat treatment of welds. Since the repair welds will not be post-weld heat treated, the NRC staff agrees with the licensee that these paragraphs do not apply to the proposed repair method.

NB-4622.8 establishes exemptions from post-weld heat treatment for nozzle to component welds and branch connection to run piping welds. NB-4622.8(a) establishes criteria for exemption of post-weld heat treatment for partial penetration welds. The NRC staff agrees with the licensee that NB-4622.8(a) is not applicable to the proposed repair because the criteria involve buttering layers at least 1/4-inch thick which will not exist for the welds made by the proposed temper bead process. The NRC staff finds that NB-4622.8(b) also does not apply because it discusses full penetration welds and the welds in question are partial penetration welds.

NB-4622.9 establishes requirements for temper bead repairs to P-No. 1 and P-No. 3 materials and A-Nos. 1, 2, 10, or 11 filler metals. The NRC staff agrees with the licensee that NB-4622.9 does not apply to the proposed repairs because the proposed repairs will use a filler metal (F-No. 43) that is different from the above requirements.

NB-4622.10 establishes requirements for repair welding to cladding after post-weld heat treatment. The NRC staff agrees with the licensee that NB-4622.10 does not apply because the proposed repair alternative does not involve repairs to cladding.

NB-4622.11(a) requires surface examination prior to repair in accordance with Article NB-5000. The NRC staff find that the licensee has satisfied this requirement because the proposed alternative will include surface examination prior to repair.

NB-4622.11(b) contains requirements for the maximum extent of repair. The NRC staff finds that the licensee has satisfied this requirement because the proposed alternative includes the same limitations on the maximum extent of repair.

NB-4622.11(c) discusses the repair welding procedure and welder qualification in accordance with ASME Section IX and the additional requirements of Article NB-4000. The NRC staff finds that the licensee has satisfied this requirement because the proposed alternative will satisfy these requirements, except for the stipulations of paragraph QW-256 of ASME Section IX. The NRC staff evaluation of QW-256 is discussed later.

NB-4622.11(c)(1) requires the area to be welded be suitably prepared for welding in accordance with the written procedure to be used for the repair. The NRC staff finds that the licensee has satisfied this requirement because the proposed alternative will include welding preparation which is discussed in Attachment 1 to the August 2, 2004, submittal.

NB-4622.11(c)(2) requires the use of the shielded metal arc welding process with covered electrodes meeting either the A-No. 8 or F-No. 43 classifications. The proposed alternative uses gas tungsten arc welding with bare electrodes meeting the F-No. 43 classification. The temper bead gas tungsten arc welding technique is based on many acceptable procedure qualification records and welding procedure specifications which have been used to perform numerous successful repairs. The temper bead process has been shown effective by research, successful procedure qualifications, and many successful repairs performed since the technique was developed. It has been shown that adequate toughness can be achieved in base metal and heat affected zones with the use of a temper bead technique by gas tungsten arc welding. Therefore, the NRC staff finds that the gas tungsten arc welding based on the temper bead process is acceptable for use in lieu of the shield metal arc welding process.

NB-4622.11(c)(3) discusses requirements for covered electrodes pertaining to hermetically sealed containers or storage in heated ovens. The NRC staff finds that these requirements do not apply because the proposed alternative uses bare electrodes, which do not require any special storage conditions to prevent the pickup of moisture from the atmosphere.

NB-4622.11(c)(4) discusses requirements for storage of covered electrodes during repair welding. The NRC staff finds that these requirements do not apply because the proposed alternative uses bare electrodes, which do not require any special storage conditions to prevent the pickup of moisture from the atmosphere.

NB-4622.11(c)(5) requires preheat to a minimum temperature of 350 °F prior to repair welding. Data from welding procedure qualification tests using the machine gas tungsten arc welding based on the ambient temperature temper bead process show that quality temper bead welds can be performed with a 50 °F minimum preheat and no post-weld heat treatment. The NRC staff agrees with the licensee that NB-4622.11(c)(5) does not apply because the proposed alternative does not require elevated preheat temperature.

NB-4622.11(c)(6) establishes requirements for electrode diameters for the first, second, and subsequent layers of the repair weld and requires removal of the weld bead crown before deposition of the second layer. The proposed alternative uses weld filler metal much smaller than the 3/32, 1/8, and 5/32 inch electrodes required by NB-4622.11(c)(6). Also, the use of the automatic or machine gas tungsten arc welding based on the ambient temperature temper bead process allows more precise control of heat input, bead placement, and bead size and contour than the manual shielded metal arc welding process required by ASME Code Sections III and

XI. The very precise control over these factors afforded by the process provides more effective tempering and eliminates the need to grind or machine the first layer of the repair. Therefore, the NRC staff finds that it is acceptable that these requirements do not apply to the proposed alternative.

NB-4622.11(c)(7) requires the preheated area to be heated from 450 °F to 660 °F for a minimum period of 4 hours. The NRC staff finds acceptable that the proposed alternative does not require this heat treatment because the use of the extremely low hydrogen gas tungsten arc welding temper bead procedure does not require the hydrogen bake-out testing.

NB-4622.11(c)(8) requires welding subsequent to the hydrogen bake-out of subparagraph NB-4622.11(c)(7) be done with a minimum preheat of 100 °F and maximum interpass temperature of 350 °F. The proposed alternative limits the interpass temperature to 350 °F and requires the area to be welded be at least 50 °F prior to welding. NRC staff's detailed evaluation of this requirement is discussed in Section 4.6.2 of this safety evaluation.

NB-4622.11(d)(1) requires a liquid penetrant examination after the hydrogen bake-out described in subparagraph NB-4622.11(c)(7). The proposed alternative does not require the hydrogen bake-out because the low-hydrogen, ambient-temperature temper bead welding process makes it unnecessary. However, the licensee will perform a post-weld liquid penetrant examination. The NRC staff finds the proposed alternative satisfies NB-4622.11(d)(1) and, therefore, is acceptable.

NB-4622.11(d)(2) requires penetrant testing and radiographic testing of repair welds after a minimum of 48 hours at ambient temperature. Also, repair welds shall be volumetrically examined, if practical, by the ultrasonic method after the completed repair weld has been at ambient temperature for at least 48 hours. The proposed alternative requires liquid penetrant and ultrasonic examination. The NRC staff agrees with the licensee that the geometry of the reactor vessel closure head and the orientation of the inner bore of the reactor vessel closure head nozzles make effective radiographic testing impractical. The thickness of the reactor vessel closure head limits the sensitivity of the detection of defects in the new pressure boundary weld. The density changes between the base and weld metal and residual radiation from the base metal would render the radiographic film image inconclusive. Due to the high area dose which would cause fogging of the film and changing radius of the reactor vessel head which would cause geometric unsharpness condition, the NRC staff concludes that radiographic testing is impractical for this type of repair.

Ultrasonic testing is used to identify features that reflect sound waves. The degree of reflection depends largely on the physical state of matter on the opposite side of the reflective surface and, to a lesser extent, on specific physical properties of the matter (density). For example, sound waves are almost completely reflected at metal-gas interfaces and partially reflected at metal-to-solid interfaces. Discontinuities that act as metal-gas interfaces, such as cracks, laminations, shrinkage cavities, and bonding faults, are easily detected. Inclusions and other metal inhomogeneities can also be detected by partial reflection of the sound wave. The NRC staff believes that the use of ultrasonic testing coupling with a surface examination will provide an acceptable inspection. On the basis of above evaluation, the NRC staff finds that ultrasonic examination and surface examination are acceptable alternative to radiographic testing of the new welds.

NB-4622.11(e) establishes the requirements for documentation of the weld repairs in accordance with subarticle NB-4130. The licensee stated that the proposed alternative will comply with these requirements. Therefore, the NRC staff finds NB-4622.11(e) is satisfied.

NB-4622.11(f) establishes requirements for the procedure qualification test plate. The licensee stated that the proposed alternative complies with these requirements. Therefore, the NRC staff finds NB-4622.11(f) is satisfied.

NB-4622.11(g) establishes requirements for welder performance qualification relating to physical obstructions that might impair the welder's ability to make sound repairs which is particularly pertinent to the manual shielded metal arc welding process. The proposed alternative involves a machine gas tungsten arc welding process and requires welding operators be qualified in accordance with ASME Section IX. The NRC staff finds that the proposed alternative is acceptable because the use of a machine welding process as is proposed herein eliminates concern about obstructions, which might interfere with the welder's abilities to make sound welds.

NB-4453.4 requires that the examination of repair welds be conducted in accordance with the requirements of the original welds. The proposed welds will be partial penetration welds as defined in NB-4244(d) and will meet the weld design requirements of NB-3352.4(d). The proposed partial penetration welds require examination in accordance NB-5245 which specifies a progressive surface examination. The licensee proposed to perform a surface examination and ultrasonic examination of the completed weld in lieu of a progress surface examination. The NRC staff finds that the proposed alternative provides adequate nondestructive examinations and is, therefore, acceptable.

NB-5330(b) does not allow any cracks or incomplete penetration regardless of length. As a result of the geometry, a linear indication may occur at the intersection of the reactor vessel closure head, the nozzle, and the first intersecting weld bead (triple point). The proposed alternative will allow this triple point indication to remain. The licensee evaluated this indication as a potential crack and showed that it is structurally stable. The NRC staff's evaluation of the triple point is discussed later. The NRC staff finds the proposed alternative is acceptable with respect to NB-5330(b) because the anomaly is shown, by analysis, to be stable.

QW-256 of ASME Section IX requires that the maximum interpass temperature during procedure qualification be no more than 100 °F below that used for actual welding. The maximum interpass temperature during welding is specified to be 350 °F. The maximum interpass temperature during the procedure qualification was less than 100 °F. The NRC staff finds the proposed alternative acceptable because QW-256 is satisfied.

Code Case N-638, Section 2.1(b) requires consideration be given to the effects of welding in a pressurized environment. The NRC staff agrees with the licensee that this requirement is not applicable because the welding will not occur in a pressurized environment.

Code Case N-638, Section 2.1(c) requires consideration be given to the effects of irradiation on the properties of materials in the reactor vessel belt line region. The NRC staff agrees with the

licensee that this requirement is not applicable because the welding will be performed on the reactor vessel closure head, not in the reactor vessel belt line region.

Code Case N-638, Section 2.1(h) specifies Charpy V notch requirements for ferritic weld material of the procedure qualification. The filler material is F-No. 43, which is not ferritic. The NRC staff agrees with the licensee that this requirement does not apply.

Code Case N-638, Section 3.0(c) requires a layer of weld reinforcement be applied and then machined to a flush surface. The NRC staff agrees with the licensee that this requirement is not applicable because the welding will join dissimilar metals with non-ferritic weld filler metal and, therefore, a layer of weld reinforcement will not be needed. This issue is discussed in Section 4.6.2 of this safety evaluation.

Code Case N-638, Section 3.0(d) specifies the maximum interpass temperature for field applications shall be 350 °F regardless of the interpass temperature during qualification. Code Case N-638 2.1(e) specifies the maximum interpass temperature for the first three layers of the test assembly shall be 150 °F. Subsection QW-256 specifies maximum interpass temperature as a supplementary essential variable that must be held within 100 °F above that used during procedure qualification. The NRC staff finds that the proposed welding procedures are consistent with Code Case N-638, Sections 2.1(e) and 3.0(d) and; therefore, the proposed alternative is acceptable.

Code Case N-638, Section 3.0(e) requires care be taken to ensure that the weld region is free of all potential sources of hydrogen. The proposed welding procedure is inherently free of hydrogen; therefore, the NRC staff finds this requirement is satisfied.

Code Case N-638, Section 4.0(b) requires surface and ultrasonic examinations of the final weld surface and band around the weld area. However, the licensee stated that the band around the weld area cannot be examined due to the physical configuration of the partial penetration weld and interference from adjacent nozzles. In its response to NRC staff's question, dated October 4, 2004, the licensee stated that the final examination of the new weld and immediate surrounding area within the bore will be based on Figures 3 and 4 in Attachment 1 to the August 2, 2004, submittal. The ultrasonic testing will be performed by scanning from the inner diameter surface of the weld, the adjacent portion of the original nozzle, and the top of the new lower nozzle. The volume of interest for ultrasonic testing extends from at least ½-inch above and below the new weld into the low alloy steel of the reactor vessel closure head to at least ¼-inch depth. The penetrant testing area includes the weld surface and extends upward on the original nozzle inside surface to include the abrasive water jet remediated surface (approximately 2.7 inches on the control rod drive nozzles and approximately 3.1 inches on the incore instrumentation nozzles) and at least ½-inch below the new weld on the lower nozzle inside surface. The final examination of the new weld and immediate surrounding area of the weld within the band will be sufficient to verify that defects have not been induced in the low alloy steel reactor vessel closure head material due to the welding process, and will assure integrity of the nozzle and the new weld. The NRC staff finds the proposed alternative acceptable because in lieu of N-638 4.0(b), the licensee will inspect the weld and associated area to the extent no less than stated above.

Code Case N-638, Section 4.0(c) requires areas which had attached thermocouples to be ground and examined using a surface examination. This requirement will be met if thermocouples are used. The NRC staff finds the proposed alternative acceptable because the licensee will satisfy this requirement if thermocouples are used.

Code Case N-638, Section 4.0(e) requires ultrasonic testing acceptance criteria to be in accordance with IWA-3000. The proposed welding technique requires ultrasonic testing acceptance criteria in accordance with NB-5330, which is consistent with the original construction code requirements. The NRC staff questioned the licensee on the use of NB-5330. In the October 4, 2004, letter, the licensee stated that for the weld configuration in question, there are no acceptance criteria in IWB-3000 that directly apply. Therefore, the criteria in Section III NB-5330 are used. These criteria are generally more restrictive than Section XI standards because the NB-5330 standards do not permit many common welding flaws such as lack of fusion, incomplete penetration, or cracks, regardless of length. Section XI, IWB-3000 standards allow acceptance of these types of fabrication indications based on dimensioned flaw boundaries. Based on the licensee's response, the NRC staff finds the proposed alternative acceptable.

4.6.2 STAFF EVALUATION OF PROPOSED TEMPER BEAD TECHNIQUE

The licensee's proposed temper bead technique is discussed in Attachment 1 to the August 2, 2004, letter. The licensee's discussion includes general requirements, welding qualifications, procedure qualifications, performance qualifications, welding procedure requirements, examination and documentation. The NRC staff's evaluation of the temper bead technique is as follows:

According to Code Case N-638, Section 1.0(d), the weld area plus a band around the repair area of at least 1½ times the component thickness or 5 inches, whichever is less, shall be preheated and maintained at a minimum temperature of 300 °F for the gas tungsten arc welding process during welding while the maximum interpass temperature is limited to 450 °F. The alternative ambient temperature temper bead technique also establishes a preheat band of at least 1½ times the component thickness or 5 inches, whichever is less. However, the ambient temperature temper bead technique requires a minimum preheat temperature of 50 °F, a maximum interpass temperature of 150 °F for the first three layers, and a maximum interpass temperature of 350 °F for the balance of welding. This is suitable because the heat penetration of subsequent weld layers is carefully applied to produce overlapping thermal profiles that develop an acceptable degree of tempering in the underlying heat affected zone. This is further demonstrated in EPRI report GC-111050, wherein repair welds performed with an ambient temperature temper bead procedure utilizing the machine gas tungsten arc welding process exhibit mechanical properties equivalent to or better than those of the surrounding base material. Laboratory testing, analysis, successful procedure qualifications, and successful repairs have all demonstrated the effectiveness of this process.

In the October 4, 2004, letter, the licensee stated that its welding procedure qualification tests have been performed on P-No. 3 Group No. 3 base materials using Alloy 52 filler metal at ambient (essentially room) temperature. These welding procedures were developed in accordance with ASME Section XI, Code Case N-638. Based on this data, the interpass temperature specified in alternative is acceptable.

According to Code Case N-638, Section 3.0(c), the repair cavity shall be buttered with six layers of weld metal in which the heat input of each layer is controlled to within ± 10 percent of that used in the procedure qualification test, and heat input control for subsequent layers shall be deposited with a heat input equal to or less than that used for layers beyond the sixth in the procedure qualification. The licensee proposes to butter the repair cavity or weld area with at least three layers of weld metal to obtain a minimum butter thickness of 1/8-inch. The heat input of each layer in the 1/8-inch thick buttered section shall be controlled to within ± 10 percent of that used in the procedure qualification test. The heat input for subsequent weld layers shall not exceed the heat input used for layers beyond the 1/8-inch thick buttered section (first three weld layers) in the procedure qualification.

The alternative ambient temperature temper bead technique uses a machine gas tungsten arc welding process which is a low heat input process. Subsequent gas tungsten arc welding weld layers introduce heat into the heat affected zone produced by the initial weld layer. The heat penetration of subsequent weld layers is carefully applied to produce overlapping thermal profiles that develop a correct degree of tempering in the underlying heat affected zone. When welding dissimilar materials with nonferritic weld metal, the area requiring tempering is limited to the weld heat affected zone of the ferritic base material along the ferritic fusion line. After buttering the ferritic base material with at least 1/8-inch of weld metal (first 3 weld layers), subsequent weld layers should not provide any additional tempering to the weld heat affected zone in the ferritic base material. Therefore, less restrictive heat input controls are adequate after depositing the 1/8-inch thick buttered section. Based on Charpy V-notch testing of the procedure qualification test coupon, impact properties in weld heat affected zone were greater than those of the unaffected base material. Therefore, the proposed heat input controls of alternative provides an appropriate level of tempering and the proposed alternate is acceptable.

According to Code Case N-636, Section 3.0(c), at least one layer of weld reinforcement shall be deposited on the completed weld with this reinforcement being subsequently removed by mechanical means. The alternative reinforcement layer is not removed. A reinforcement layer is required when a weld repair is performed to a ferritic base material or ferritic weld using a ferritic weld metal. The weld reinforcement layer is deposited to temper the last layer of untempered weld metal of the completed repair weld. However, when repairs are performed to dissimilar materials using nonferritic weld metal, a weld reinforcement layer is not required because nonferritic weld metal does not require tempering. When performing a dissimilar material weld with a nonferritic filler metal, the only location requiring tempering is the weld heat affected zone in the ferritic base material along the weld fusion line. However, the three weld layers of the 1/8-inch thick butter section are designed to provide the required tempering to the weld heat affected zone in the ferritic base material. Therefore, a weld reinforcement layer is not required.

Code Case N-638, Section 3.0(c) only requires the deposition and removal of a reinforcement layer when performing repair welds on similar (ferritic) materials. Repair welds on dissimilar materials are exempt from the removal of the reinforcement. Non-ferritic filler metals, such as, the F-No. 43 filler metal do not undergo a phase change at elevated temperature and therefore do not require a post-weld heat treatment. Since the last layer of weld metal is a non-ferritic metal being deposited over two previous non-ferritic weld filler metal layers, the need for a

tempering layer and its removal is unnecessary. Therefore, the NRC staff finds that the deletion of this requirement is acceptable.

4.6.3 STAFF EVALUATION OF THE NEW REPAIR WELD

The new repair weld will be a part of primary system pressure boundary. As such, the weld needs to satisfy General Design Criterion 14 of Appendix A to 10 CFR Part 50, which requires that the reactor coolant pressure boundary be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture. 10 CFR 50.55a(a)(1) and 10 CFR 50.55a(a)(2) require that ASME Code be followed. The licensee performed stress analyses of the new repair weld in accordance with the ASME Section III. In its fatigue stress analyses, the licensee considered all pressure and thermal stresses from normal and upset transient loading conditions. The fatigue analyses of the new weld concluded that the fatigue usage factor for 27 years of operation is 0.73 for the control rod drive weld repair and 0.682 for the incore instrumentation weld repair. The licensee's analyses demonstrated that the proposed weld repair design meets the stress and fatigue criteria in ASME Code, Section III, 1989 Edition, no addenda.

The licensee also performed flaw evaluations in accordance with ASME Section XI. The licensee stated that the repair weld could contain an indication referred to as a "weld anomaly." The weld anomaly is the unusual solidification patterns that may result at the intersection (triple point) of the low alloy steel of the vessel head base metal, the replacement nozzles, and filler Metal 52 of the repair weld. At the triple point location, the licensee postulated a 0.100-inch deep semicircular flaw extending 360 degrees around the circumference and performed linear elastic fracture mechanics analyses to demonstrate the acceptability of the flaw. The flaw is assumed to propagate in each of the two directions on the uphill and downhill sides of the nozzle. Flaw acceptance is based on the 1989 ASME Code Section XI criteria for applied stress intensity (IWB-3612) and limit load (IWB-3642).

The NRC staff questioned the basis of assuming an initial flaw depth size of 0.1-inch. In the October 4, 2004, letter, the licensee responded that during initial mock-up testing, triple point weld anomalies were found in some of the mockups. The triple point weld anomalies found were less than 0.100-inch deep, therefore, a conservative triple point weld anomaly of 0.100-inch deep and 360-degree semi-circular flaw around the circumference of the nozzle was assumed. Indications of 0.100-inch have not been observed in inspections of the 67 reactor vessel closure head repair welds that the licensee's vendor has performed to date. Based on the mockup tests, the NRC staff finds that the assumed initial flaw depth size of 0.1 inch is acceptable.

The stresses used for the flaw evaluation are the sum of weld residual stresses and operating stresses (pressure and thermal) due to transient events. The total stress is used to calculate stress coefficients for use with a closed-form solution to calculate the final stress intensity factor at the crack tip. In the October 4, 2004, letter, the licensee stated that stress intensity factors are calculated from worst-case stresses for the eight transients. The maximum stresses are due to safety valve operations and the minimum stresses occur during the heatup/cooldown transient.

The licensee's fracture mechanics evaluations of the new repair weld showed that:

- (1) A postulated 0.100-inch flaw at the triple point is acceptable for 27 years of operation following the nozzle weld repair.
- (2) Fatigue crack growth of the postulated flaw is minimal along each flaw propagation path. The stress intensity factors of the final flaw sizes for the control rod drive nozzle and incore instrumentation nozzle satisfy the safety margin of $\sqrt{10}$ per ASME Section XI, IWB-3612.
- (3) The margin on the limit load analysis for the control rod drive nozzle and incore instrumentation nozzle satisfy the required margin of 3.0 per ASME Section XI, IWB-3642.

The staff finds that the weld anomaly is stable and, therefore, acceptable because the licensee's flaw evaluation showed that it satisfies the criteria in IWB-3612 and IWB-3642.

The licensee also evaluated the life expectancy of the proposed weld repair with respect to the primary water stress-corrosion cracking (PWSCC) concerns of the remaining Alloy 600 control rod drive nozzle portion affected by the proposed weld repair. The Alloy 690 replacement lower nozzle and Alloy 52 weld are not considered susceptible to PWSCC. The licensee stated that if the proposed weld repair is not remediated with an abrasive water jet machining procedure, the life expectancy relative to PWSCC is estimated at 1.3 effective full power years for a control rod drive nozzle and 1.5 effective full power years for an incore instrumentation nozzle. If a water jet procedure is used, the life expectancy relative to PWSCC is estimated at 53 EFPY for control rod drive nozzles and incore instrumentation nozzles. As discussed in Section 3 of this safety evaluation, the licensee will perform a water jet machining procedure on the surface of the repair weld which will increase the life expectancy of the repair weld.

As a result of the proposed nozzle repair, a region/space in the reactor vessel closure head penetration between the original nozzle and replacement nozzle will be exposed to the primary coolant. The licensee evaluated the reactor vessel closure head base metal for potential general corrosion, galvanic corrosion, crevice corrosion, stress corrosion cracking and hydrogen embrittlement. Galvanic corrosion, crevice corrosion, stress corrosion cracking, and hydrogen embrittlement of the reactor vessel closure head are not significant concerns based on operational experience with low alloy steel exposed to primary coolant. The general corrosion rate for the reactor vessel closure head, under the anticipated exposure conditions, is 0.0032 inches/year. This corrosion rate is based on an 18-month operating cycle followed by a 2-month refueling cycle. The NRC staff finds this corrosion rate is low and will not affect the structural integrity of the reactor vessel closure head.

On the basis of the licensee's stress analyses and flaw evaluation, the NRC staff finds that the new repair weld satisfies the requirements of ASME Sections III and XI, and reasonable assurance of structural integrity will be provided.

4.7 CONCLUSION

On the basis of the NRC staff's evaluation, the staff concludes that the licensee's proposed alternatives to flaw repair and inspection for the control rod drive nozzles and incore instrumentation nozzles of the reactor vessel closure head provide an acceptable level of quality and safety. Therefore, pursuant to 50.55a(a)(3)(i) of 10 CFR, the NRC staff authorizes Relief Request No. 1, the NRC staff authorizes the proposed alternatives for the repair of the control rod drive nozzles and incore instrumentation nozzles of the reactor vessel closure head through the end of the third 10-year inservice inspection interval at the Palisades Nuclear Plant. All other requirements of the ASME Code, Sections III and XI for which relief has not been specifically requested and approved remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

5.0 RELIEF REQUEST NO. 2 - FLAW CHARACTERIZATION OF REMNANT WELD

5.1 STAFF EVALUATION OF THE NEW REPAIR WELD

The components for which relief is requested are the reactor vessel closure head, 45 control rod drive nozzle penetrations, and 8 incore instrumentation nozzle penetrations.

5.2 APPLICABLE ASME CODE EDITION AND ADDENDA

The ASME Code Section XI, 1989 Edition with no addenda is applicable for Relief Request No. 2.

5.3 APPLICABLE ASME CODE REQUIREMENT

ASME Section XI, IWB-2500, examination Category B-E, Items B4.12 and B4.13 are applicable to the inservice examination of the J-groove welds associated with the control rod drive nozzles and incore instrumentation nozzles.

ASME Section XI, IWB-3142.4 allows for analytical evaluation to demonstrate that a component is acceptable for continued service. It also requires that components found acceptable for continued service by analytical evaluation be subsequently examined in accordance with IWB-2420(b) and (c).

ASME Section XI, IWA-3300(b) contains a requirement for flaw characterization.

ASME Section XI, IWB-3420 requires the characterization of flaws in accordance with the rules of IWA-3300.

5.4 LICENSEE'S PROPOSED ALTERNATIVE

In lieu of ASME Section XI, IWB-3142.4, successive examination will not be performed because analytical evaluation of the worst-case flaw has been performed to demonstrate the acceptability of continued operation and the impracticality of performing any subsequent inspection that would be able to characterize any remaining flaw.

In lieu of ASME Section XI, IWA-3300(b), a conservative worst-case flaw shall be assumed to exist in this weld that extends from the weld surface to the reactor vessel closure head low alloy steel base material interface. Appropriate fatigue analyses have been performed based on that flaw to establish the minimum remaining service life of the reactor vessel closure head.

In lieu of ASME Section XI, IWB-3420, a conservative worse-case flaw shall be assumed to exist and appropriate fatigue analyses have been performed based on that flaw.

5.5 LICENSEE'S BASIS FOR THE PROPOSED ALTERNATIVE

The proposed alternative is based on fracture mechanics evaluations by Framatome (AREVA Document 32-5044161-00, "Palisades CRDM [control rod drive mechanism] Nozzle IDTB [inside diameter tempered bead] J-groove Weld Flaw Evaluation," dated July 2004 (Proprietary), and AREVA Document 32-5045743-00, "Palisades ICI [incore instrumentation] Nozzle IDTB J-groove Weld Flaw Evaluation," dated July 2004 (Proprietary)). The fracture mechanics evaluations determine if degraded J-groove weld material could be left in the reactor vessel closure head without the need to perform successive examinations to size any flaws that might remain following the repair. Since hoop stresses in the J-groove weld are higher than the axial stress at the same location, the preferential direction for cracking is axial, or radial relative to the nozzle. It was postulated that a radial flaw in the Alloy 182 weld metal would propagate by primary water stress corrosion cracking through the weld and butter to the interface with the low alloy steel head, where the flaw would blunt and arrest. To reduce the size of the postulated flaw, the repair design specifies that the inside corner of the J-groove weld be chamfered.

The licensee stated that crack growth through the Alloy 182 material would tend to relieve the residual stresses in the weld as the crack grew to its final size and blunted. Although residual stresses in the head material are low, the size of the postulated flaw was increased to include the region where the residual stresses are tensile. It was then not necessary to further consider residual stresses for crack growth into a compressive residual stress field. It was further postulated that a small flaw could initiate in the low alloy steel head material and combine with the large stress corrosion crack in the weld to form a radial corner flaw that would propagate further into the low alloy steel head by fatigue crack growth under cyclic loading associated with heat up, cool down, and other applicable transients.

The results of the analysis for the control rod drive nozzle demonstrate that a postulated radial crack in the remnant of the original J-groove weld and butter would satisfy the 1989 ASME Code, Section XI criteria (IWB-3612) for 27 years of operation, with a minimum fracture toughness margin of 3.51. A similar flaw in the incore instrumentation nozzle would be acceptable for 5 years, when the ratio of material fracture toughness to applied stress intensity factor would be 3.16 (or $\sqrt{10}$), which is the maximum permitted by IWB-3612.

5.6 DURATION OF THE RELIEF

The licensee requested approval of the proposed relief for the remainder of the third 10-year interval of the inservice inspection which will conclude on or before December 12, 2006.

5.7 STAFF EVALUATION

The proposed repair plan removes the lower half of the original nozzle from inside the reactor vessel closure head penetration and welds the replacement nozzle to the mid-wall of the penetration. This repair action changes the examination category of the remnant J-groove weld. After the repair is complete, the remnant J-groove weld no longer falls under IWB-2500, Examination Category B-E Item B4.12 and becomes a non-pressure retaining weld, which is part of the base metal thickness. The new repair weld is now treated as the pressure retaining weld and is considered to fall under Examination Category B-E Item B4.12.

The NRC staff agrees with the licensee that ultrasonic examination of any flaws in the original J-groove weld region is ineffective and impractical due to the configuration of the reactor vessel closure head. The angle of incidence from the outer surface of the closure head base material does not permit perpendicular interrogation by ultrasonic shear wave techniques of circumferentially oriented flaws and the physical proximity of the nozzle does not allow for longitudinal scrutiny of the area of interest. If examination of the J-groove weld were to be attempted from the inner diameter of the head, the cladding provides an acoustic interface which severely limits a confident examination of the weld material. Radiographic testing of the weld area is also ineffective due to orientation of circumferentially oriented flaws being perpendicular to gamma and x-rays. In addition, surface examinations will not provide any useful volumetric information. Therefore, the licensee requested leaving the original J-groove weld in service without successive examinations.

In lieu of successive examinations, the licensee postulated a worse-case flaw existed in the weld and showed, by analysis, that the postulated flaw is stable at the end of the operating license. This approach is based on the premise that the worse-case flaw in the remnant weld can be demonstrated to be structurally stable at the end of the operating license. Therefore, the structural integrity and leakage integrity of the reactor vessel closure head will not be compromised. Thus, the successive examinations of the remnant weld required by ASME Section XI will not be needed.

For the flaw evaluation, the licensee assumed a worst-case radial flaw in the J-groove weld and that the entire J-groove weld and butter are cracked due to PWSCC. The crack was assumed to extend from the weld surface to the interface between the butter and the base metal of the reactor vessel closure head.

The licensee also assumed that a fatigue-initiated flaw forms in the vessel head base metal. This fatigue flaw is combined with flaw due to PWSCC in the weld to form a large radial corner flaw that was assumed to propagate into the head by fatigue crack growth under cyclic loading conditions. The purpose of this analysis is to determine how far the postulated flaw would propagate into the vessel head base metal and whether the final crack would compromise structural integrity and leakage integrity of the reactor vessel closure head.

The NRC staff asked the licensee to clarify how the weld residual stresses are considered in the flaw evaluation. In the October 4, 2004, letter, the licensee responded that residual stresses transition from tensile in the area of the weld to compressive at some distance into the reactor vessel closure head. These stresses were addressed by increasing the size of the original postulated flaw size in the weld and butter to include the zone of tensile residual stress in the head. Thus, residual stresses are not reduced by compressive stresses in the head, but rather, tensile residual stresses are relieved as the crack propagates through the weld and butter and

into the head. The demarcation between tensile and compressive residual stress was determined along the bored surface since this is the location of the highest stress intensity factor. Residual hoop stresses along the bored surface of the head were taken from stress analysis, starting from the butter/head interface. The transition from tensile to compressive stress occurs at a distance of 0.640 inch into the reactor vessel closure head.

The licensee stated that the size of the postulated flaw (in the weld and butter) along the bored surface was then increased by 0.64 inch to account for the presence of residual stresses. The other characteristic flaw parameter, the horizontal distance "a", was also increased by 0.64 inches.

Four finite element models were generated to evaluate the postulated flaw; a stress model to obtain residual stresses, a stress model to obtain operating (fatigue) stresses, and two crack models to generate stress intensity factor influence coefficients for evaluating the range of flaw sizes produced by fatigue crack growth. The stress intensity factor influence coefficients were used to generate unit stresses that were distributed over the crack face crack tip. The influence coefficients are intended to represent flaws that are similar in shape to the postulated flaws. The licensee's flaw evaluation showed that the postulated flaw sizes are close to the analytical flaw size, which validates the crack models that calculate the influence coefficients for use in the flaw evaluations.

The licensee calculated fatigue crack growth up to 27 years using cyclic loading conditions including pressure and temperature. Fatigue crack growth was used to calculate the final flaw size at the end of 27 years. Stress intensity factors were calculated for the final crack size using the influence coefficients derived from the finite element crack models. The licensee then compared the stress intensity factor of the final flaw size to the limiting stress intensity factor (i.e., crack arrest) of the reactor vessel closure head based on the fracture toughness of the low alloy steel. ASME Section XI, IWB-3612 requires that the postulated flaw maintains a safety margin of $\frac{1}{2}$ for the accident condition and $\frac{1}{4}$ for normal and upset conditions when comparing the crack tip stress intensity factor to the crack arrest stress intensity factor. The licensee's flaw evaluations showed that the final flaw size has satisfied the safety margins required by ASME Section XI, IWB-3612.

The NRC staff finds that successive examinations of the remnant J-groove weld are not needed because the worst-case flaw in the remnant weld is demonstrated by analysis to be acceptable in accordance with the safety margins of the ASME Section XI, IWB-3612.

5.8 CONCLUSION

On the basis of the NRC staff's evaluation, the staff determines that compliance with the Code requirements regarding flaw characterization and successive examinations of the remnant welds is impractical. Therefore, pursuant to 10 CFR 50.55a(g)(6)(i), relief is granted from the requirements of ASME Section XI, IWA-3300, IWB-3142.4, IWB-3420 pertaining to the remnant J-groove welds of the control rod drive nozzles and incore instrumentation nozzles in the reactor vessel closure head at the Palisades Nuclear Power Plant through the end of the third 10-year inservice inspection interval. This grant of relief is authorized by law and will not endanger life or property or the common defense and security and is otherwise in the public interest giving

due consideration to the burden upon the licensee that could result if the requirements were imposed on the facility.

All other requirements of the ASME Code, Sections III and XI for which relief has not been specifically requested and approved remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

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